National Aeronautics and Space Administration

NASA's Turbine Electrified Energy Management (TEEM) Control

Aeropropulsion Performance Benefits Realized Through Operability

Challenge

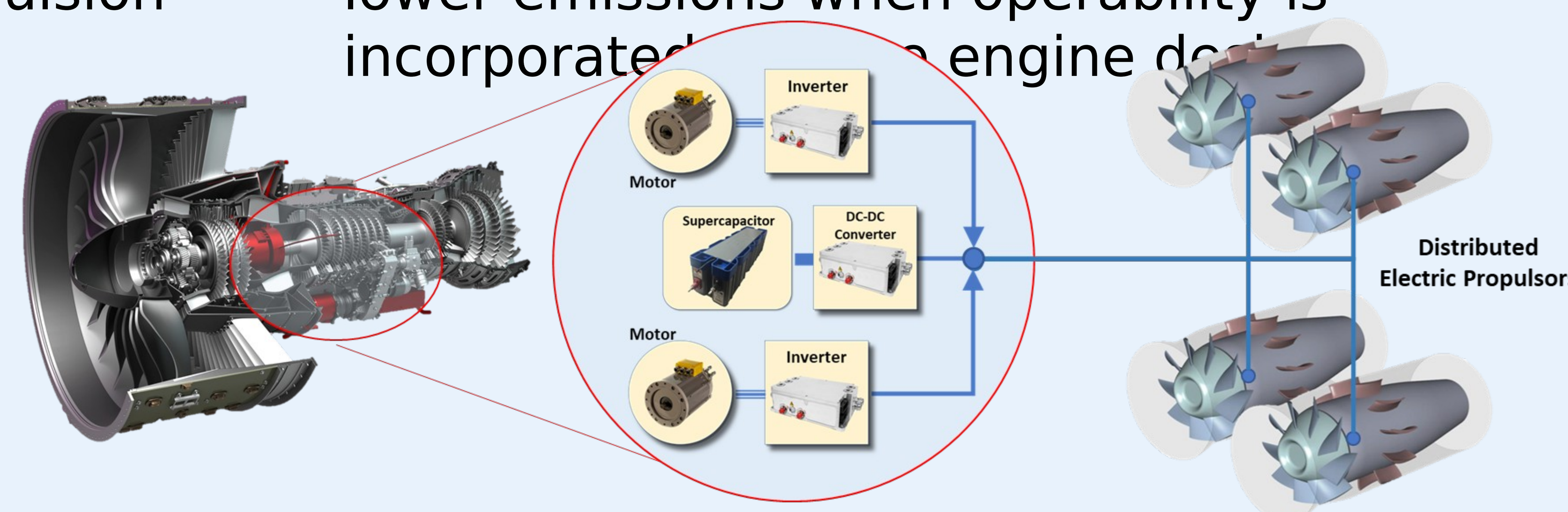
- Increasingly, system dynamics are the performance limiting factors in gas turbine engines..
- In design, the typical approach is to avoid dynamic effects by holding large design margins that add weight and volume.
- With hybridization and operability improvements these obstacles can be overcome for a step change in propulsion system performance.

Expected Impacts

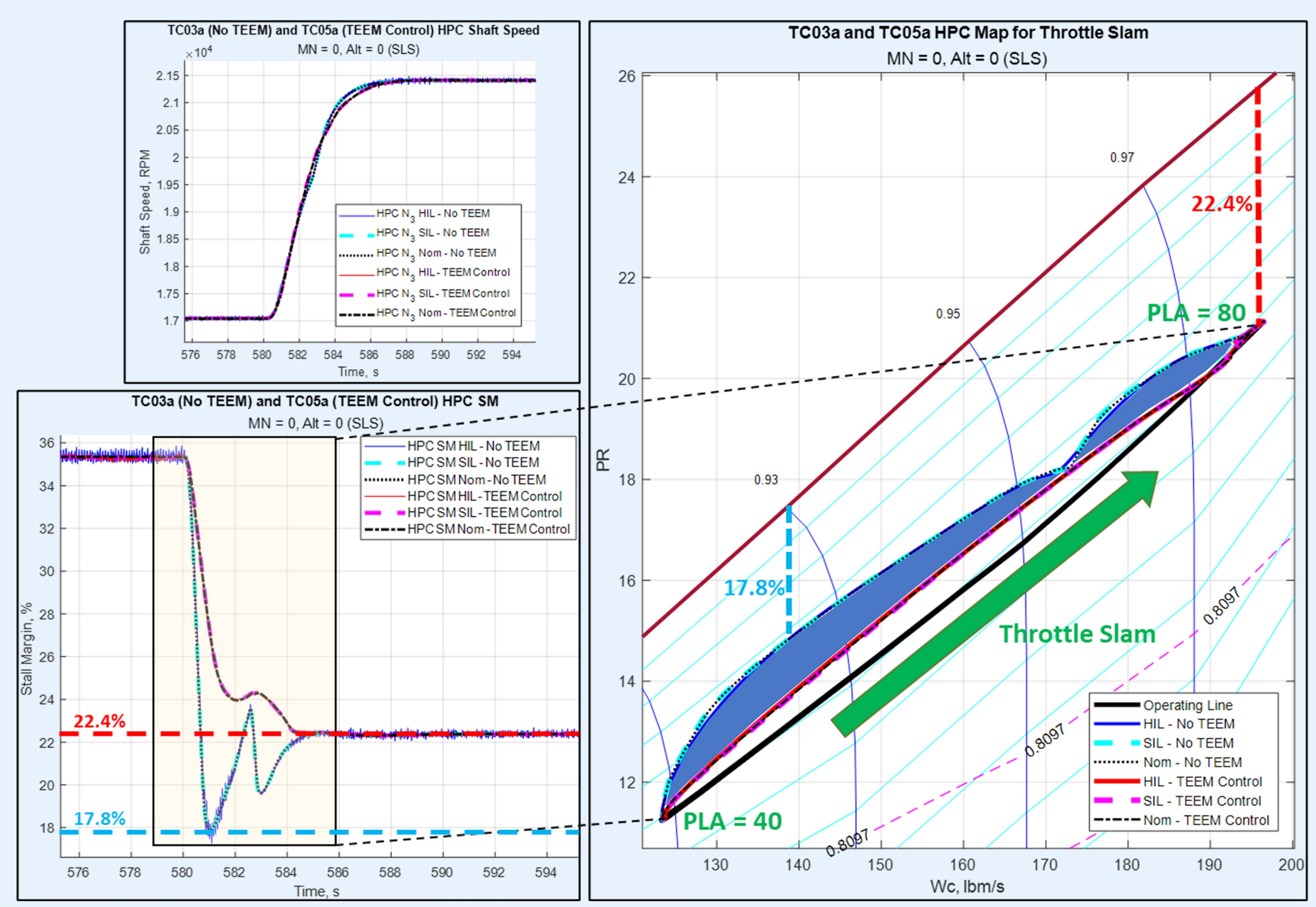
- Many existing turbine engines can gain stability, longer life, and improved responsiveness.
- New hybrid propulsion systems and aircraft can achieve critical performance metrics, with increased safety, redundancy, and reliability.
- Future engines will be smaller and lighter with improved efficiency and lower emissions when operability is incorporated … e engine de…

A typical hybrid electric propulsion architecture consists of a gas turbine engine driving an electric power system that supports one or more electric propulsors.

An electrical energy storage element is used to decouple the gas turbine from the load thus assisting the turbine engine shaft response and avoiding flow instabilities in the gas path.



The High-Pressure Compressor (HPC) response is shown using a time series of speed and stall margin (left) and the performance map (right). The blue lines indicate the HPC's natural underdamped response to a large acceleration power change. The red lines demonstrate the controlled response using TEEM. The area colored in blue on the map indicates unused stall margin that can exchanged for performance benefits.



Solution

- Dynamics are caused by energy storage mechanisms; shaft rotation, gas path pressure variations, and heat.
- Leveraging the electric machines in hybrid propulsion architecture allows manipulation of shaft dynamics to reduce instability caused by gas dynamics and excess heat.
- This frees design margin to be traded for performance benefits such as reduced weight/volume, increased power, and improved efficiency.

Results

System dynamics are critical to the safety, reliability, and performance of complex systems. Demonstrating that we can control dynamics, instead of avoiding them, is a game changing technology for future system design and capability.

Next Steps

This technology is being adopted by NASA demonstration projects with plans to be tested on engines at full scale.

Engine design tools are being developed to investigate the extent that gas path flow incidence angle can be controlled to realize lower loss blading and increased power density.

Partners and/or Participants

- NASA ARMD, Advanced Air Vehicle Program, Hybrid Thermally Efficient Core
- NASA ARMD, Integrated Aviation Systems Program, Electrified Powertrain Flight Demo
- NASA ARMD, Transformative Aeronautics Concepts Program, Convergent Aeronautics Solutions, SUSAN

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IMAGINAVIATION